offspring spend the first 4–6 weeks of their life in the burrow and regularly leave it and can be trapped after another 4 weeks. The reason that to date *Hypogeomys* was reported to have only one single offspring per year (Petter 1972; Starck 1974; Cook et al. 1991), might be due to a high offspring mortality rate. Radiotracking and capture/recapture studies revealed a mean offspring mortality of more than 50% (Sommer 2000).

In order to investigate the body mass development of early and late born offspring of consecutive litters born during one reproductive period and possible sex specific differences, the body mass of all offspring trapped between March and June were analysed (Fig. 1). The body mass development of early and late born female offspring and late born male offspring can be described by a significant linear regression (female offspring: early born: $R^2 = 0.46$, $p = 0.002$, late born: $R^2 = 0.74$, $p = 0.003$; male offspring: early born: $R^2 = 0.09$, n. s., late born: $R^2 = 0.53$, $p = 0.01$). The present data do not indicate that male and female offspring differ in the development of their body mass (ANOVA: early born: $F_{1,28} = 2.7$, n. s., late born: $F_{1,20} = 0.75$, n. s.). The difference of body mass of early and late born offspring during one reproductive period decreases with increasing age in their first year of life. At the end of the dry season (Nov/Dec), female offspring weighed 866 ± 177 g ($n = 11$) and male offspring 863 ± 99 g ($n = 5$) (t-test: n. s.). Also the analyses of other body measurements (body-, tail-, ear-, hindfoot-, head length, and head width) did not show any age-dependent differences in male and female offspring (Sommer 1998).

Although the study indicated that *H. antimena* can have more offspring per couple and year than suggested previously, the reproductive rate is still very low. The survival prospects of this endangered species is critical due to changing environmental and ecological conditions as a consequence of the increasing human impact on the remaining habitat (Sommer and Hommen 2000).

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Author's address:
Dr. SIMONE SOMMER, Zoologisches Institut und Museum, Universität Hamburg, Martin-Luther-King-Platz 3, D-20146 Hamburg. (email: Simone.Sommer@zoologie.uni-hamburg.de).

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Short communication

Mating behavior during the estrus cycle in female Mongolian gerbils (*Meriones unguiculatus*)

By R. Weinandy, Sylvia Hofmann, and R. Gattermann

Institute of Zoology, Martin-Luther-University Halle-Wittenberg, Halle, Germany

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Mongolian gerbils (*Meriones unguiculatus*) are common socially living rodents in the Steppe and semi-desert regions of Mongolia and Mandchuria (Gromov 1990). In their natural habitat, families, grouped around a founder pair, are strictly territorial (Ågren et al. 1989). Male behavior has been shown to be influenced by females (Probst and Lorenz 1987). Since the current literature on the female estrus cycle is limited and ambiguous (Marston and Chang 1965; Nishino and Totsukawa 1996), a redescription appears to be necessary. The aim of the present study was to obtain detailed data on the four stages of the estrus cycle in the Mongolian gerbil.

Adult Mongolian gerbils (*Meriones unguiculatus*) of both sexes from different litters aged 12–28 weeks were selected for this study. They were derived from our own laboratory stock (Zoh : CRW) and were kept in climatised windowless rooms under a photoperiod of LD = 14 : 10 (lights on at 0500 h CET; 200–300 lx during the light phase, approximately 5 lx during the dark phase). The room temperature was 23 ± 2° C and the relative humidity varied between 65 and 70%. The animals were housed in plastic cages (55 × 33 × 20 cm) with a wire mesh top. Tap-water and food pellets (Altromin® 7024, Altromin GmbH, Lage) were provided ad libitum. The animal bedding (Allspan®, NL) was renewed every two weeks.

Initially, the four different stages of the estrus cycle were defined in adult females (n = 18) by taking vaginal smears daily between two to four hours after lights on, over a period of two months. The stained smears were microscopically analysed (Leica®, Type DMRBE, ×200).

In figure 1 the respective pattern of the four stages of the estrus cycle is depicted. Some females remained in diestrus for up to 14 days, i. e., the cycle became irregular or was arrested for that period of time. However, it was always followed by the preestrus and the estrus cycle proceeded regularly.

Mating tests were performed during the four different stages of the estrus cycle of the gerbils. To prevent gravidity, adult but sexually unexperienced males were sterilized by vasectomy. Two weeks after surgery they were taken to perform mating tests. Vaginal smears were taken from all 24 females to evaluate their stage of estrus cycle two hours before the start of the mat-

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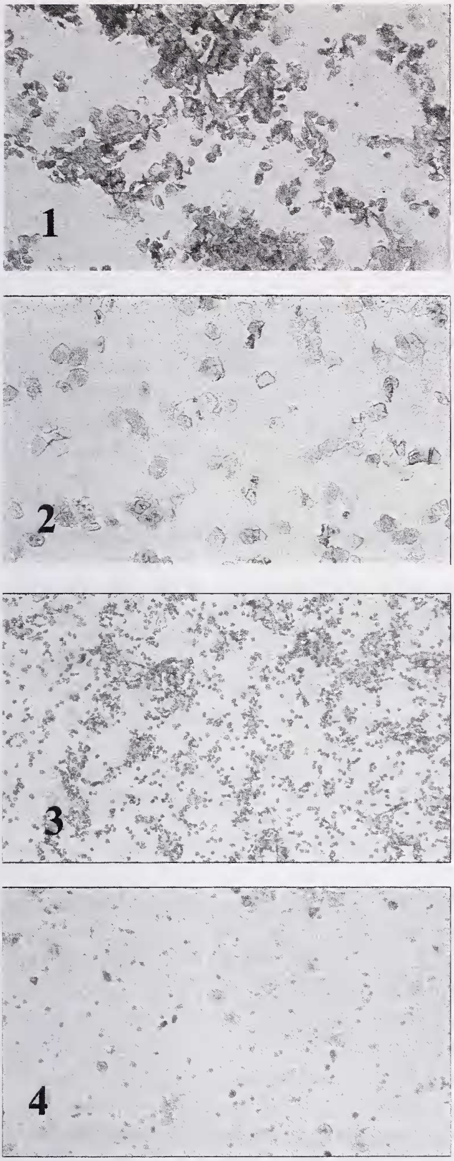

Fig. 1. Vaginal smears during the estrus cycle. Photographed under microscope (×200).
1. Preestrus: high number of squamous epithelial cells, absence of leukocytes and almost no cornified epithelial cells; 2. Estrus: low number of squamous epithelial cells, high number of dispersed cornified epithelial cells and no leukocytes; 3. Metestrus: mainly leukocytes, isolated squamous epithelial cells and/or cornified epithelial cells; 4. Diestrus: low number of leukocytes, no or only a few squamous epithelial cells and/or cornified epithelial cells.

ing tests (20–30 minutes after lights off). The lowest number of females, to which a stage could be unambiguously assigned, counted 11. In the following, always 11 out of 24 females were randomly chosen before every mating test. For each stage the animals were tested in a clean cage with new animal bedding. Ten minutes before the female was introduced, a vasectomized male was put into the cage. Each test lasted for ten minutes and the frequency of the following activities of the females was registered: copulation [c]: female is mounted by the male combined with friction movements; copulation trials [ct]: female presses tail to bottom and prevents the male, which tries to mount the female; lordosis [l]: female remains in front of the male with bent hind paws and lifted tail; copulation avoidance behavior [cab]: female poses head towards the male, vocalizes and/or avoids the male, genitals and tail are directed away. Kruskal-Wallis analysis of variance and subsequent two-tailed Mann-Whitney U-test (Winstat V 3.1) were used to assess differences in the mating tests. Since multiple tests were run on the same basic dataset, the resulting p-values were corrected by the standard Bonferroni procedure. Differences were accepted as significant at $p < 0.05$ (* in Fig. 2).

Figure 2 shows the results of the mating tests. The copulation behavior occurred exclusively in estrus (Kruskal-Wallis H-test: H-value = 20.23, $n = 11$, $p < 0.05$; Mann-Whitney U-Test estrus vs. preestrus, metestrus and diestrus: in all cases $U = 27.5$, $p = 0.0346$). The number of copulation trials was highest during the preestrus and lowest at diestrus. This difference was significant (Kruskal-Wallis H-test: H-value = 10.86, $n = 11$, $p < 0.05$; Mann-Whitney U-Test preestrus vs. estrus: $U = 31$, n. s.; preestrus vs. metestrus: $U = 26.5$, n. s.; preestrus vs. diestrus: $U = 16$, $p = 0.0188$; estrus vs. metestrus: $U = 48$, n. s.; estrus vs. diestrus: $U = 35.5$, n. s.; metestrus vs. diestrus: $U = 50.5$, n. s.). The lordotic behavior was mainly shown in the estrus (Kruskal-Wallis H-test: H-value = 18.37, $n = 11$, $p < 0.05$; Mann-Whitney U-Test preestrus vs. estrus:

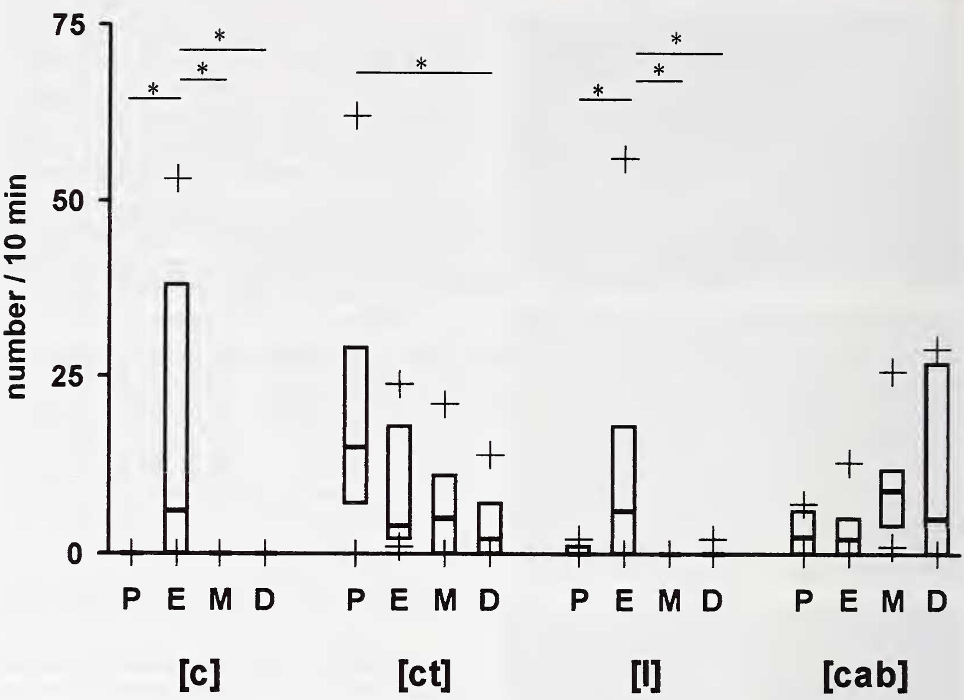

Fig. 2. Frequency of behavioral parameters during the mating tests. Females (n = 11) were tested during preestrus (P), estrus (E), metestrus (M) and diestrus (D).
[c] = copulation; [ct] = copulation trials; [l] = lordosis; [cab] = copulation avoidance behavior. Median values and the interquartils are shown, differences are significant at $p < 0.05$ and given as asterisks in the graph.

U = 21.5, p = 0.0369; preestrus vs. metestrus: U = 44, n. s.; preestrus vs. diestrus: U = 57, n. s.; estrus vs. metestrus: U = 16.5, p = 0.0048; estrus vs. diestrus: U = 20.5, p = 0.0244; metestrus vs. diestrus: U = 12.5, n. s.). There were no significant differences concerning copulation avoidance behavior towards the males during the estrus cycle (Kruskal-Wallis H-test: H-value = 7.21, n = 11, n. s.). The morning after the females were tested in estrus, 7 of the 24 tested females developed a vaginal plug.

In various rodents the uterus and the vagina as targets of ovarian hormones show cycle-dependent proliferation and apoptosis of luminal and glandular epithelium (SATO et al. 1997). The periodical increase and decrease of squamous epithelial cells, leukocytes and cornified epithelial cells in vaginal smears is a consequence of these changes and has already been described for rats (OTHA 1995) or golden hamsters (SANDOW et al. 1979; GATTERMANN et al. 1985) and reliably indicates the estrus. In gerbils, the preestrus used to be characterized by an increased number of squamous epithelial cells and the absence of leukocytes (NISHINO and TOTSUKAWA 1996). The aggressiveness of the females was low and they displayed only minor copulation avoidance behavior towards the males. This belongs to precopulatory behavior which may have a proceptive function (HOLMAN et al. 1985). The estrus stage is a period of characteristic behavior including sexual receptivity (lordotic posture) in confrontation with males and the related vaginal smear pattern has already been described (BARFIELD and BEEMANN 1968; ADAMS and NORRIS 1973; VICK and BANKS 1969). A further indicator for the re-